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Straw Buildup in Soil with Stubble Mulch Fallow in the Semiarid Great Plains[1]

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ABSTRACT

The quantity of wheat (*Triticum aestivum* L.) straw in the 0 to 7.6 cm depth of soil in wheat-fallow rotations was determined at Sidney, Montana, Akron, Colorado, North Platte, Nebraska, and Bushland, Texas. Rotation treatments varied between locations but included straw rates, dates of primary tillage, and straw burial times. Types of primary tillage were also studied with continuous wheat at Bushland, Texas.

Quantities of straw found mixed in the surface 7.6 cm of soil at the four Great Plains locations ranged from 1,300 to 7,480 kg/ha. The straw quantities found are influenced by duration of wheat-fallow rotation, date, and type of primary tillage and straw burial time but were not proportional to the rates of straw mulch used at the beginning of fallow. In a long-term study plots at Bushland, Texas, straw build-up was significantly greater with continuous wheat than with wheat-fallow. Adding nitrogen fertilizer even at high rates did not influence the amount of straw found in soil at Sidney, Montana or North Platte, Nebraska.

Additional Index Words: soil straw, straw mulch, fallow, subsurface tillage.

In the Great Plains, wheat (*Triticum aestivum* L.) straw is the primary mulching material used to assist in wind erosion control and improve soil water storage during fallow (4, 5). Straw mulches have also been reported (3) to improve organic matter conditions resulting in increased N mineralization and available P. Prior to 1961, much of the research involving straw mulches was conducted in subhumid to humid climates and with intensive types of tillage (5). Straw mulch effects on a number of soil-water-plant relationships have been summarized (5). Research concerning straw mixed with surface soils is meager, but Unger and Parker (9) reported that cumulative evaporation from soil over a 16-week period was reduced 57 and 19% by surface straw and buried straw, respectively, compared with where straw was mixed with the surface 3 cm of soil. In the Great Plains, 50 to 80% of the straw mulch disappears from the surface during a 14-month fallow season depending on the tillage system used. Previously, straw buried by tillage was usually assumed to decompose quite rapidly. However, samples from five commercial farms in northeastern Colorado where a wheat-fallow rotation had been used for more than 10 years showed an average of 4,600 kg/ha undecomposed straw mixed in the surface 7.6 cm of soil. Thus, straw disappearance from the surface of these soils was not associated with rapid and complete decomposition.

Since straw mixed with soil did not appear to decompose rapidly in the Great Plains, an investigation was conducted at four Great Plains locations to determine how tillage operations, cropping systems, and initial amounts of surface straw influenced the amount of straw found mixed with the soil.

Hereafter the term soil straw is defined as that quantity of straw actually mixed with surface soils, as differentiated from straw mulches found on the soil surface.

MATERIALS AND METHODS

Soil straw was determined at Sidney, Montana, North Platte, Nebraska, and Akron, Colorado, from stubble mulch experiments described previously (4). Straw mulch rates used in fallow ranged from 0 to 6,720 kg/ha at Sidney, 3,360 to 10,080 kg/ha at North Platte, and from 1,680 to 6,720 kg/ha Akron. Three dates of straw burial by disking during fallow were tested at North Platte and three dates of initial subtillage were used at Akron. At Sidney, nearly all straw remaining on the soil surface at the end of fallow was incorporated with a tandem disk just before wheat seeding.

Stubble mulch plots begun in 1942 at Bushland, Texas, included fallow vs. continuous wheat; two dates and two types of primary tillage with fallow; and three types of primary tillage with continuous wheat. The average amount of straw available for mulching after harvest was about 3,000 kg/ha for fallow-wheat and 2,450 kg/ha for continuous wheat, but the amounts varied considerably with crop years.

Sampling Procedure—Straw on the soil surface was removed and soil samples (2 kg) were collected from the 0- to 7.6-cm soil depth. A minimum of eight samples was taken from each experimental treatment after wheat had been planted with equal numbers of samples taken from the drill ridge and drill furrow. Straw was washed from the soil with a fine stream of water, collected on a double 18-mesh screen, and dried at 70C. Straw was then separated from gravel by floating off the larger particles and by successive filterings and washings of the mixture until the gravel was clean.

RESULTS AND DISCUSSION

Soil straw increased as the amount of straw available for fallow increased at all locations (Table 1). The larger straw particles were easily identified and were brown and grey-brown. Some finer particles were identified as glumes and awns and these appeared to be quite resistant to decomposition. The quantity of "skeleton" straw material, which resists decomposition, apparently increased as rates of straw available for decomposition increased. However, the percentage of the initial surface straw found in the soil de-

Table 1—Influence of rates of straw mulch and number of fallow cycles on quantities of soil straw at three Great Plains locations

Straw mulch per fallow cycle	Two fallow cycles		Three fallow cycles	
kg/ha	kg/ha	% recovered	kg/ha*	% recovered
		Sidney, Montana		
1,680	1,300 a	39	2,100 a	42
3,360	1,670 b	25	2,810 b	28
6,720	1,800 b	13	3,410 c	17
		North Platte, Nebraska		
3,360	--	--	3,010 a	30
6,720	--	--	3,260 ab	16
10,080	--	--	3,620 b	12
		Akron, Colorado		
1,680	2,040 a	61	3,020 a	61
3,360	2,880 b	43	4,300 b	43
6,720	4,570 c	34	5,810 c	29

* Means within unbroken columns not followed by the same letter are significantly different at the 5% level.

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Table 2—Influence of date and type of primary tillage; and time of straw burial on quantities of soil straw at three Great Plains locations

Tillage variable		Soil straw kg/ha*
		Akron, Colorado†
Date of primary subtillage		
Summer sweep	(Aug. 5)	3,940 a
Early spring sweep	(Apr. 5)	4,490 ab
Mid-spring sweep	(May 5)	4,690 b
		North Platte, Nebraska†
Time straw burial		
Summer oneway disk	(late July)	2,150 a
Spring oneway disk	(late April)	2,430 b
End fallow oneway disk	(early Sept.)	2,820 c
No burial - sweep	(all operations)	3,010 c
		Bushland, Texas†
Date of primary tillage		
Summer oneway disk	(July)	1,940 a
Summer sweep	(July)	3,470 b
Spring sweep	(April)	4,570 c
Average		3,330
		Bushland, Texas‡
Type primary tillage		
Oneway disk	(July)	2,800 a
Lister and chisel	(July)	4,830 b
Sweep	(July)	7,480 c
Average		5,040

* Means within unbroken columns not followed by the same letter are significantly different at the 5% level.
† Fallow-wheat rotation, three cycles 1963 to 1967, Akron, Colorado and North Platte, Nebraska; since 1942 at Bushland, Texas.
‡ Continuous wheat since 1942.

creased with increased application rates of straw mulch. This may have occurred for two reasons. First, some of the straw mulch used for the higher rates of application was hand applied and not in an anchored upright position. This permitted greater contact with the soil and may have hastened decomposition of the more easily decomposable fraction. Secondly, each type of tillage implement used during fallow consistently incorporates a given percentage of the straw on the soil surface regardless of amount present (1, 5). Thus, more straw was incorporated into the soil from higher surface straw rates than from lower rates with each tillage operation.

At Sidney, North Platte, and Akron, the average amount of soil straw at the end of three fallow cycles (5 years) for all treatments was 24, 16, and 37% of the original surface mulch applied, respectively. The 37% recovery at Akron was 5,810 kg/ha of soil straw out of 20,160 kg/ha total straw added during the three fallow cycles. The lower values obtained at Sidney and North Platte as compared with Akron were the result of incorporating straw into the soil by disking sometime during the fallow season. Continuous subsurface tillage, as was used at Akron, is known to significantly retard straw burial as compared with disk tillage (1, 5, 10). Regardless of tillage or the amount of straw available at the beginning of fallow at each of the three locations, all treatments showed more than 2,000 kg/ha soil straw at the end of the three cycles of fallow.

The amount of soil straw increased about 1,200 kg/ha after the third cycle of wheat-fallow compared with after two cycles at Akron and Sidney (Table 1). This suggests a buildup of soil straw with increasing number of fallow cycles A continual buildup of soil straw with increasing number of fallow cycles would eventually result in tremendous quantities of soil straw. This is not likely because based on the amount of surface straw mulch available for mixing in the soil during the 25-year existence of the plots at Bushland, the soil straw has apparently reached an equilibrium. Therefore over long periods, some equilibrium will probably be reached at Akron and Sidney.

Delaying the date of primary subsurface tillage during fallow at Akron and Bushland increased the amount of soil straw as did delaying the date of disking at North Platte (Table 2). At Bushland, a single one-way disking as the primary tillage on either fallow or continuous wheat reduced the amount of soil straw about 60% compared with subtillage. Continuous wheat at Bushland retained 1,710 kg/ha more soil straw than did the wheat-fallow rotation.

At Sidney and North Platte, applications of N, even at relatively high rates during each crop year of the study, did not reduce the amount of soil straw found at either location (data not shown). These results agree with those of other investigators (6, 7) and suggest that addition of N-fertilizer to hasten decomposition of straw under semiarid conditions may be questionable.

CONCLUSION

Significant quantities of soil straw were found at four Great Plains locations under a variety of field treatments and climatic conditions. Decomposition of straw in the soil has been shown to increase with increasing soil-straw contact (2) and with increased exposure time (2, 8). Therefore, the generally used tillage practices in the Great Plains which leave the surface soil loose and the relatively dry semi-arid climate of the region tend to enhance soil straw accumulation because neither conditions nor time are favorable for decomposition. However, the limited research on straw mixed with soil reveals a need to clarify the role of soil straw on plant-soil-water-temperature relationships in the semiarid Great Plains.

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